

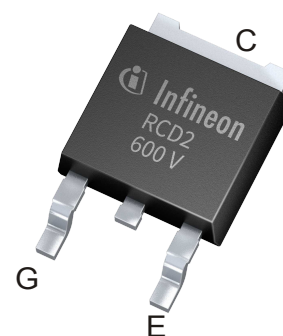
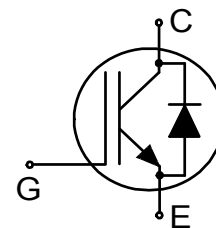
## TRENCHSTOP™ RC-Series for hard switching applications

### Cost effective monolithically integrated IGBT with Diode

#### Features:

TRENCHSTOP™ Reverse Conducting (RC) technology for 600V applications offering

- Very tight parameter distribution
- Operating range up to 20kHz
- Maximum junction temperature 175°C
- Short circuit capability of 3μs
- Humidity robust design
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models:  
<http://www.infineon.com/rc-d2>



#### Potential Applications:

- Major Home Appliances
  - Air Conditioning
  - Refrigerators
- Drives
  - GPD (General Purpose Drives)

#### Product Validation:

Qualified for industrial applications according to the relevant tests of JEDEC47/20/22



#### Key Performance and Package Parameters

Type	V <sub>CE</sub>	I <sub>C</sub>	V <sub>CEsat</sub> , T <sub>vj</sub> =25°C	T <sub>vjmax</sub>	Marking	Package
IKD04N60RC2	600V	4A	2V	175°C	K4DRC2	PG-TO252-3

### Table of Contents

Description .....	1
Table of Contents .....	2
Maximum Ratings .....	3
Thermal Resistance .....	3
Electrical Characteristics .....	4
Electrical Characteristics Diagrams .....	6
Package Drawing .....	13
Testing Conditions .....	14
Revision History .....	15
Disclaimer .....	16

## TRENCHSTOP™ RC-Series for hard switching applications

## Maximum Ratings

For optimum lifetime and reliability, Infineon recommends operating conditions that do not exceed 80% of the maximum ratings stated in this datasheet.

Parameter	Symbol	Value	Unit
Collector-emitter voltage, $T_{vj} \geq 25^{\circ}\text{C}$	$V_{CE}$	600	V
DC collector current, limited by $T_{vjmax}$ $T_c = 25^{\circ}\text{C}$ $T_c = 100^{\circ}\text{C}$	$I_C$	8.0 5.6	A
Pulsed collector current, $t_p$ limited by $T_{vjmax}$	$I_{Cpuls}$	12.0	A
Turn off safe operating area $V_{CE} \leq 600\text{V}$ , $T_{vj} \leq 175^{\circ}\text{C}$ , $t_p = 1\mu\text{s}$	-	12.0	A
Diode forward current, limited by $T_{vjmax}$ $T_c = 25^{\circ}\text{C}$ $T_c = 100^{\circ}\text{C}$	$I_F$	4.6 2.4	A
Diode pulsed current, $t_p$ limited by $T_{vjmax}$	$I_{Fpuls}$	12.0	A
Gate-emitter voltage Transient Gate-emitter voltage ( $t_p \leq 10\mu\text{s}$ , $D < 0.010$ )	$V_{GE}$	$\pm 20$ $\pm 25$	V
Short circuit withstand time $V_{GE} = 15.0\text{V}$ , $V_{CC} \leq 400\text{V}$ Allowed number of short circuits < 1000 Time between short circuits: $\geq 1.0\text{s}$ $T_{vj} = 150^{\circ}\text{C}$	$t_{SC}$	3	$\mu\text{s}$
Power dissipation $T_c = 25^{\circ}\text{C}$ Power dissipation $T_c = 100^{\circ}\text{C}$	$P_{tot}$	36.6 18.3	W
Operating junction temperature	$T_{vj}$	-40...+175	$^{\circ}\text{C}$
Storage temperature	$T_{stg}$	-55...+150	$^{\circ}\text{C}$
Soldering temperature, reflow soldering (MSL1 according to JEDEC J-STA-020)		260	$^{\circ}\text{C}$

## Thermal Resistance

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	

**R<sub>th</sub> Characteristics**

IGBT thermal resistance, <sup>1)</sup> junction - case	$R_{th(j-c)}$		-	-	4.10	K/W
Diode thermal resistance, <sup>2)</sup> junction - case	$R_{th(j-c)}$		-	-	10.10	K/W
Thermal resistance, min. footprint junction - ambient	$R_{th(j-a)}$		-	-	75	K/W
Thermal resistance, 6cm <sup>2</sup> Cu on PCB junction - ambient	$R_{th(j-a)}$		-	-	50	K/W

<sup>1)</sup> R<sub>th</sub>/Z<sub>th</sub> based on single cooling pulse. Please be aware that a correct R<sub>th</sub> measurement of the IGBT, is not possible using a thermocouple.

<sup>2)</sup> R<sub>th</sub>/Z<sub>th</sub> based on single cooling pulse. Please be aware that a correct R<sub>th</sub> measurement of the Diode, is not possible using a thermocouple.

## TRENCHSTOP™ RC-Series for hard switching applications

Electrical Characteristic, at  $T_{vj} = 25^{\circ}\text{C}$ , unless otherwise specified

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
<b>Static Characteristic</b>						
Collector-emitter saturation voltage	$V_{CEsat}$	$V_{GE} = 15.0\text{V}$ , $I_C = 4.0\text{A}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	- -	2.00 2.40	2.30 -	V
Diode forward voltage	$V_F$	$V_{GE} = 0\text{V}$ , $I_F = 4.0\text{A}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	- -	1.90 1.95	2.20 -	V
Gate-emitter threshold voltage	$V_{GE(th)}$	$I_C = 0.45\text{mA}$ , $V_{CE} = V_{GE}$	4.3	5.0	5.7	V
Zero gate voltage collector current	$I_{CES}$	$V_{CE} = 600\text{V}$ , $V_{GE} = 0\text{V}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	- -	- -	25 2500	$\mu\text{A}$
Gate-emitter leakage current	$I_{GES}$	$V_{CE} = 0\text{V}$ , $V_{GE} = 20\text{V}$	-	-	100	nA
Transconductance	$g_{fs}$	$V_{CE} = 20\text{V}$ , $I_C = 4.0\text{A}$	-	2.0	-	S
Integrated gate resistor	$r_G$			none		$\Omega$

Electrical Characteristic, at  $T_{vj} = 25^{\circ}\text{C}$ , unless otherwise specified

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
<b>Dynamic Characteristic</b>						
Input capacitance	$C_{ies}$	$V_{CE} = 25\text{V}$ , $V_{GE} = 0\text{V}$ $f = 1000\text{kHz}$	-	180	-	$\mu\text{F}$
Output capacitance	$C_{oes}$		-	10	-	
Reverse transfer capacitance	$C_{res}$		-	7	-	
Gate charge	$Q_G$	$V_{CC} = 480\text{V}$ , $I_C = 4.0\text{A}$ , $V_{GE} = 15\text{V}$	-	24.0	-	nC

## Switching Characteristic, Inductive Load

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	

IGBT Characteristic, at  $T_{vj} = 25^{\circ}\text{C}$ 

Turn-on delay time	$t_{d(on)}$	$T_{vj} = 25^{\circ}\text{C}$ , $V_{CC} = 400\text{V}$ , $I_C = 4.0\text{A}$ , $V_{GE} = 0.0/15.0\text{V}$ , $R_{G(on)} = 49.0\Omega$ , $R_{G(off)} = 49.0\Omega$ , $L\sigma = 30\text{nH}$ , $C\sigma = 32\text{pF}$ $L\sigma$ , $C\sigma$ from Fig. E Energy losses include "tail" and diode reverse recovery.	-	4	-	ns
Rise time	$t_r$		-	9	-	ns
Turn-off delay time	$t_{d(off)}$		-	90	-	ns
Fall time	$t_f$		-	41	-	ns
Turn-on energy	$E_{on}$		-	0.10	-	mJ
Turn-off energy	$E_{off}$		-	0.04	-	mJ
Total switching energy	$E_{ts}$		-	0.14	-	mJ

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Diode Characteristic, at  $T_{vj} = 25^{\circ}\text{C}$ 

Diode reverse recovery time	$t_{rr}$	$T_{vj} = 25^{\circ}\text{C}$ , $V_R = 400\text{V}$ , $I_F = 4.0\text{A}$ , $di_F/dt = 681\text{A}/\mu\text{s}$	-	80	-	ns
Diode reverse recovery charge	$Q_{rr}$		-	148.00	-	nC
Diode peak reverse recovery current	$I_{rrm}$		-	5.7	-	A
Diode peak rate of fall of reverse recovery current during $t_b$	$di_{rr}/dt$		-	-110	-	A/ $\mu\text{s}$

## Switching Characteristic, Inductive Load

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	

IGBT Characteristic, at  $T_{vj} = 175^{\circ}\text{C}$ 

Turn-on delay time	$t_{d(on)}$	$T_{vj} = 175^{\circ}\text{C}$ , $V_{CC} = 400\text{V}$ , $I_C = 4.0\text{A}$ , $V_{GE} = 0.0/15.0\text{V}$ , $R_{G(on)} = 49.0\Omega$ , $R_{G(off)} = 49.0\Omega$ , $L\sigma = 30\text{nH}$ , $C\sigma = 32\text{pF}$ $L\sigma$ , $C\sigma$ from Fig. E Energy losses include "tail" and diode reverse recovery.	-	4	-	ns
Rise time	$t_r$		-	10	-	ns
Turn-off delay time	$t_{d(off)}$		-	98	-	ns
Fall time	$t_f$		-	47	-	ns
Turn-on energy	$E_{on}$		-	0.13	-	mJ
Turn-off energy	$E_{off}$		-	0.05	-	mJ
Total switching energy	$E_{ts}$		-	0.18	-	mJ

Diode Characteristic, at  $T_{vj} = 175^{\circ}\text{C}$ 

Diode reverse recovery time	$t_{rr}$	$T_{vj} = 175^{\circ}\text{C}$ , $V_R = 400\text{V}$ , $I_F = 4.0\text{A}$ , $di_F/dt = 500\text{A}/\mu\text{s}$	-	108	-	ns
Diode reverse recovery charge	$Q_{rr}$		-	254.00	-	nC
Diode peak reverse recovery current	$I_{rrm}$		-	6.4	-	A
Diode peak rate of fall of reverse recovery current during $t_b$	$di_{rr}/dt$		-	-87	-	A/ $\mu\text{s}$

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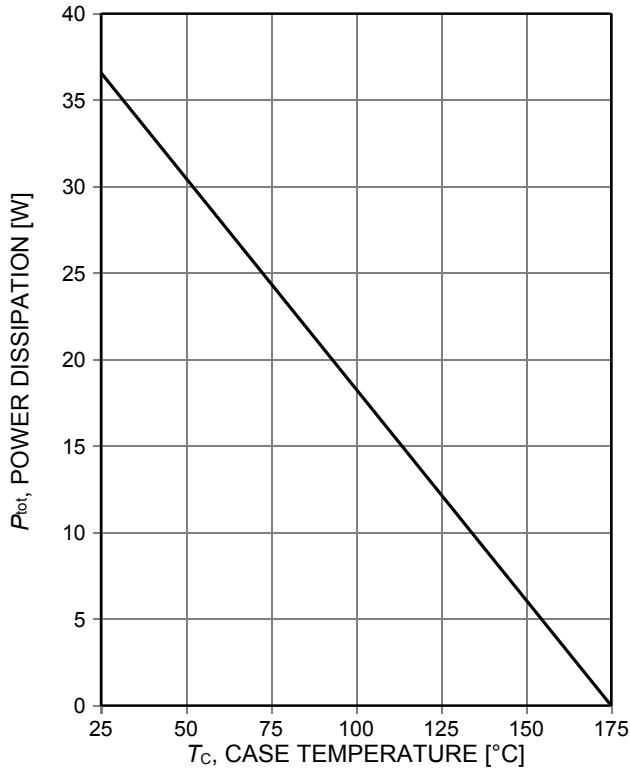


Figure 1. Power dissipation as a function of case temperature ( $T_{vj} \leq 175^\circ\text{C}$ )

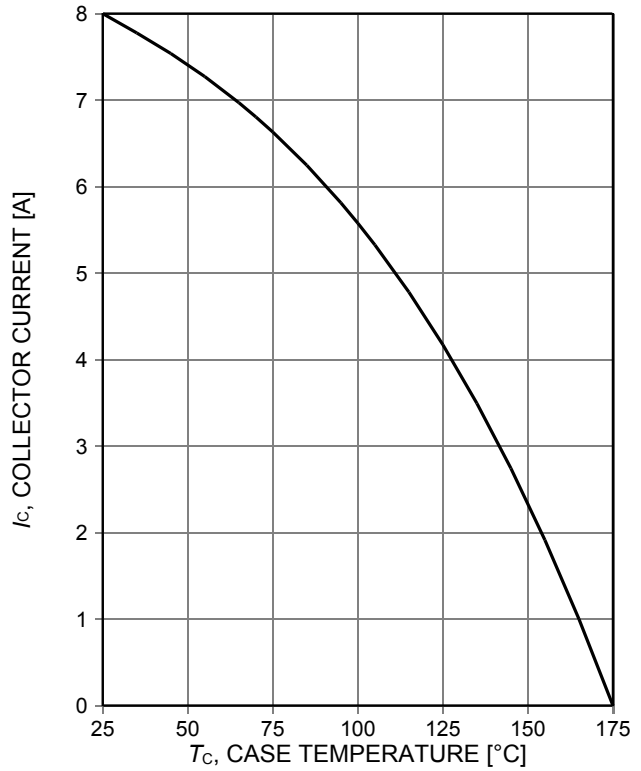


Figure 2. Collector current as a function of case temperature ( $V_{GE} \geq 15\text{V}$ ,  $T_{vj} \leq 175^\circ\text{C}$ )

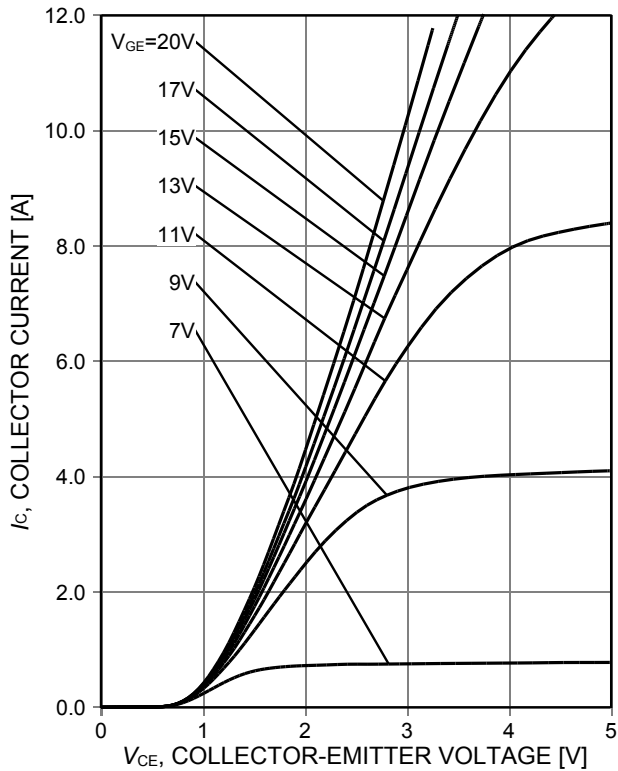


Figure 3. Typical output characteristic ( $T_{vj} = 25^\circ\text{C}$ )

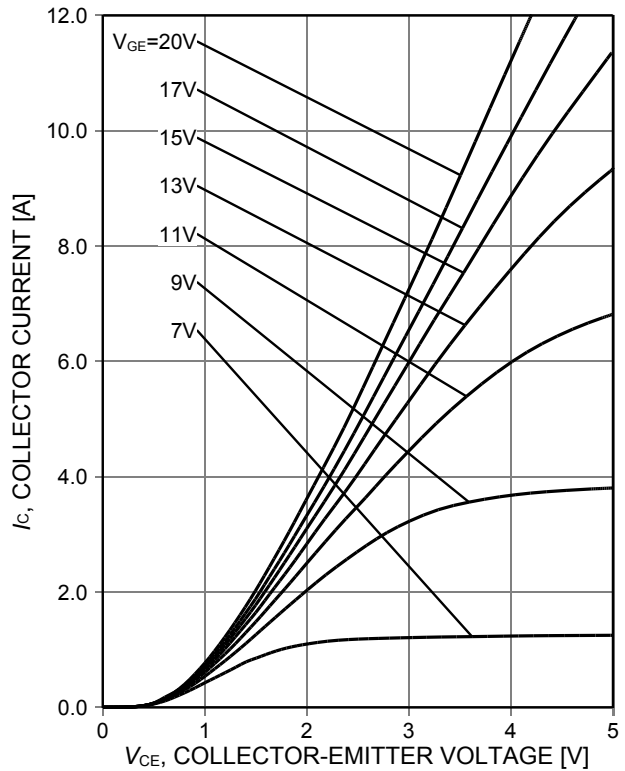


Figure 4. Typical output characteristic ( $T_{vj} = 175^\circ\text{C}$ )

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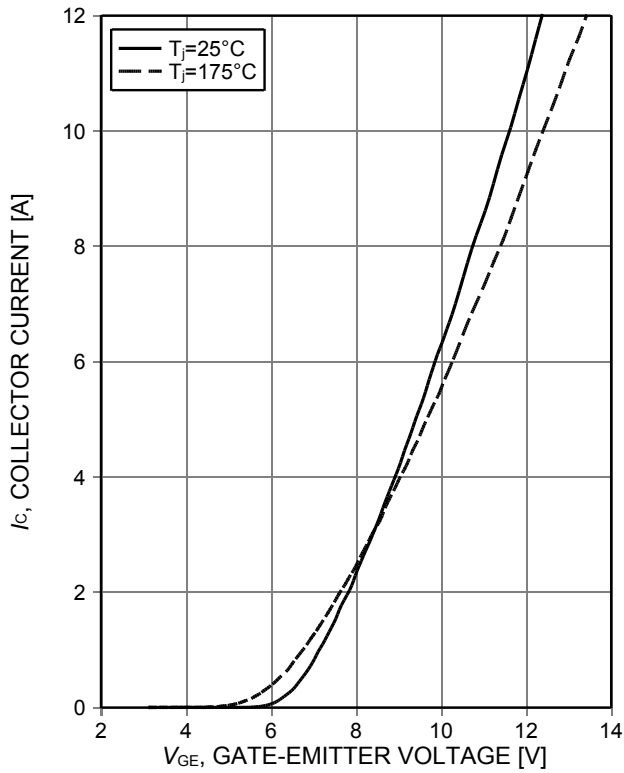


Figure 5. Typical transfer characteristic (V<sub>CE</sub>=20V)

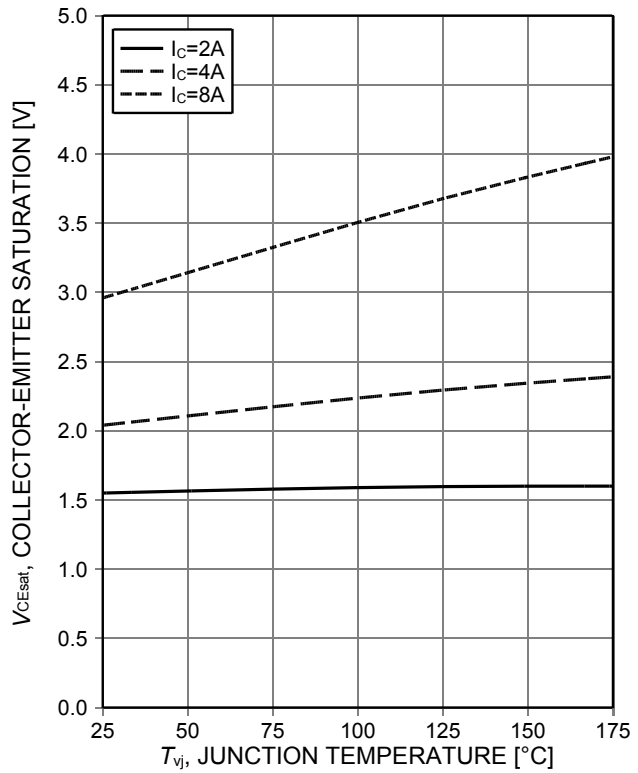


Figure 6. Typical collector-emitter saturation voltage as a function of junction temperature (V<sub>GE</sub>=15V)

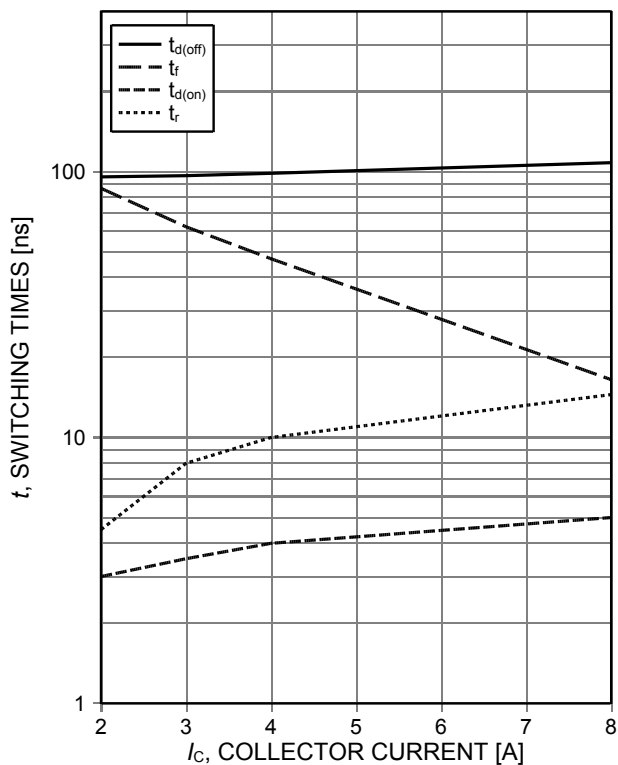


Figure 7. Typical switching times as a function of collector current (inductive load, T<sub>vj</sub>=175°C, V<sub>CE</sub>=400V, V<sub>GE</sub>=15/0V, R<sub>G</sub>=49Ω, Dynamic test circuit in Figure E)

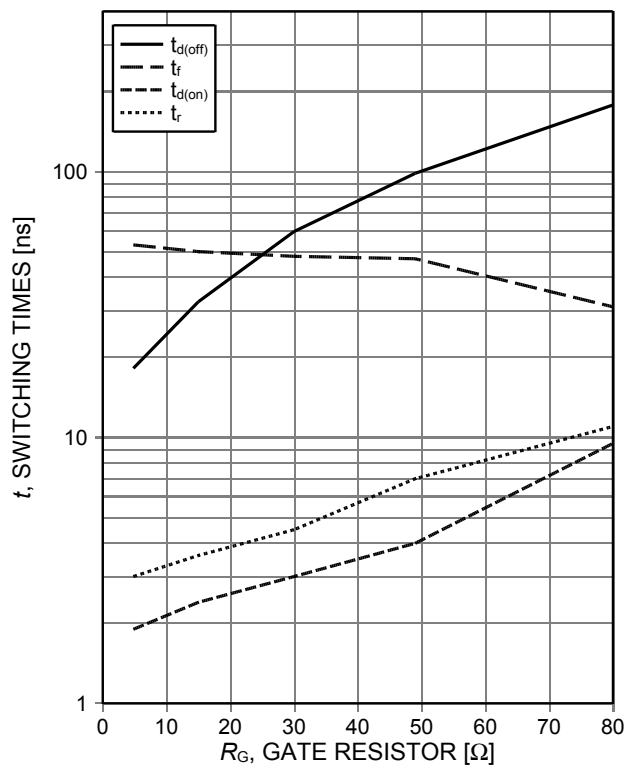


Figure 8. Typical switching times as a function of gate resistor (inductive load, T<sub>vj</sub>=175°C, V<sub>CE</sub>=400V, V<sub>GE</sub>=15/0V, I<sub>C</sub>=4A, Dynamic test circuit in Figure E)

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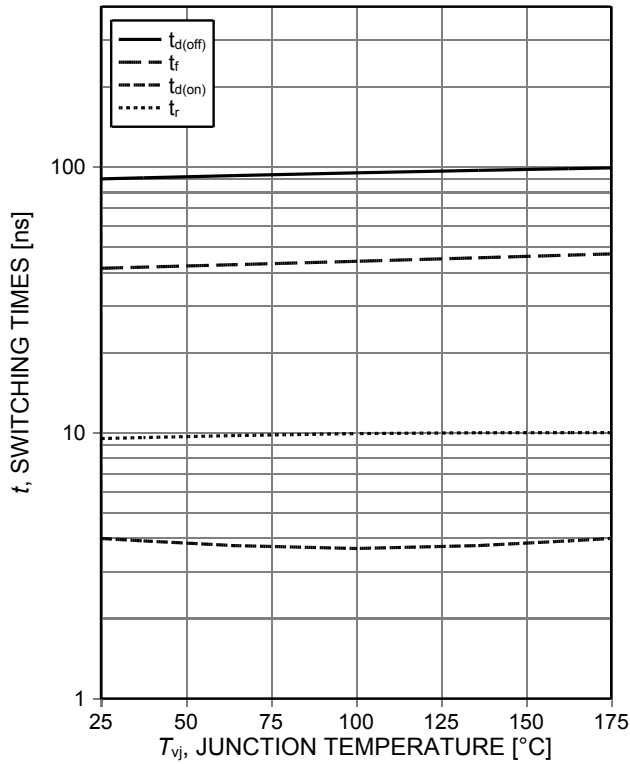


Figure 9. Typical switching times as a function of junction temperature (inductive load,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $I_C=4A$ ,  $R_G=49\Omega$ , Dynamic test circuit in Figure E)

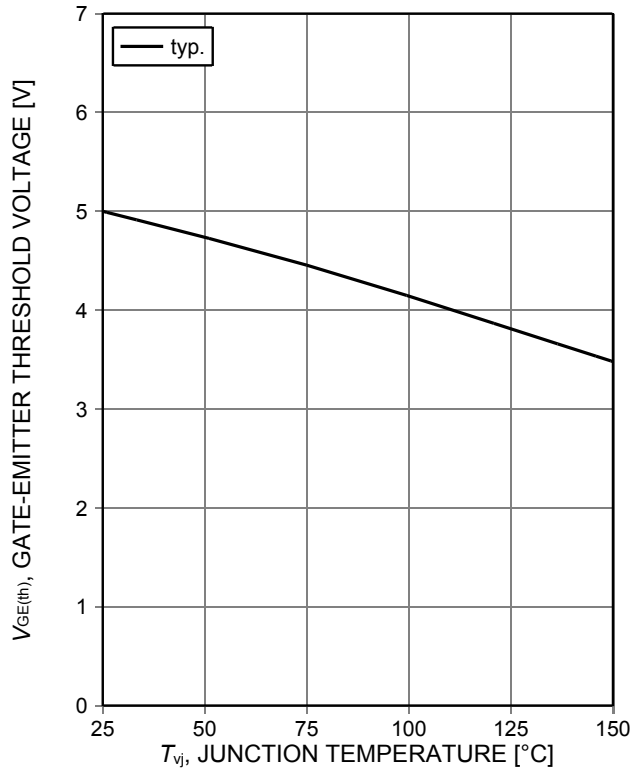


Figure 10. Gate-emitter threshold voltage as a function of junction temperature ( $I_C=0.45mA$ )

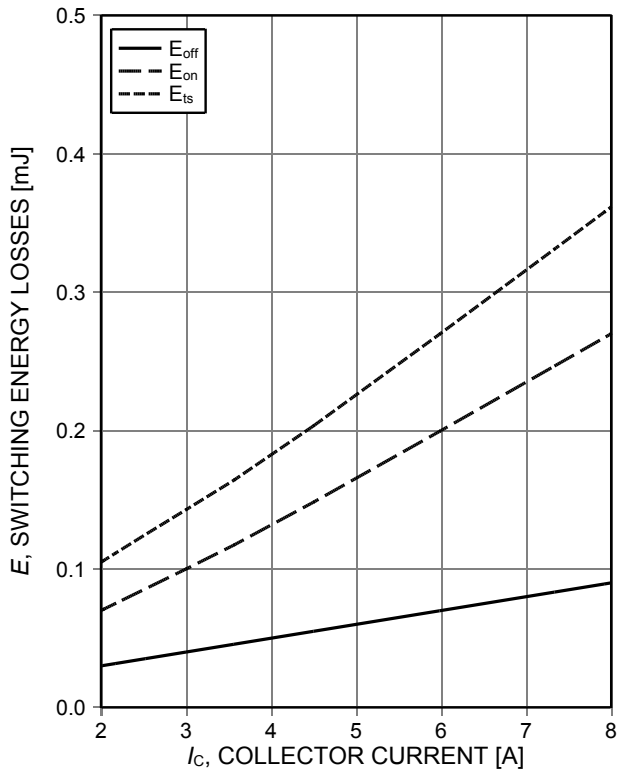


Figure 11. Typical switching energy losses as a function of collector current (inductive load,  $T_{vj}=175^\circ C$ ,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $R_G=49\Omega$ , Dynamic test circuit in Figure E)

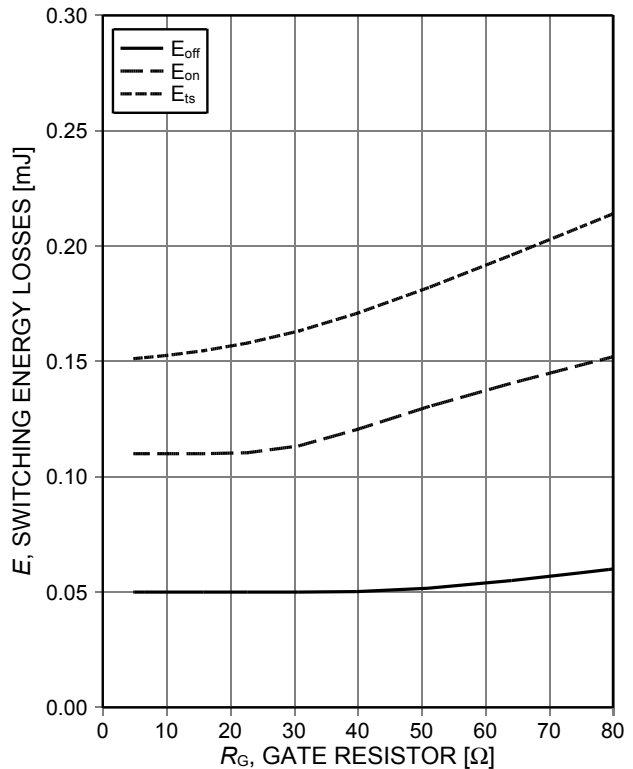


Figure 12. Typical switching energy losses as a function of gate resistor (inductive load,  $T_{vj}=175^\circ C$ ,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $I_C=4A$ , Dynamic test circuit in Figure E)



TRENCHSTOP™ RC-Series for hard switching applications

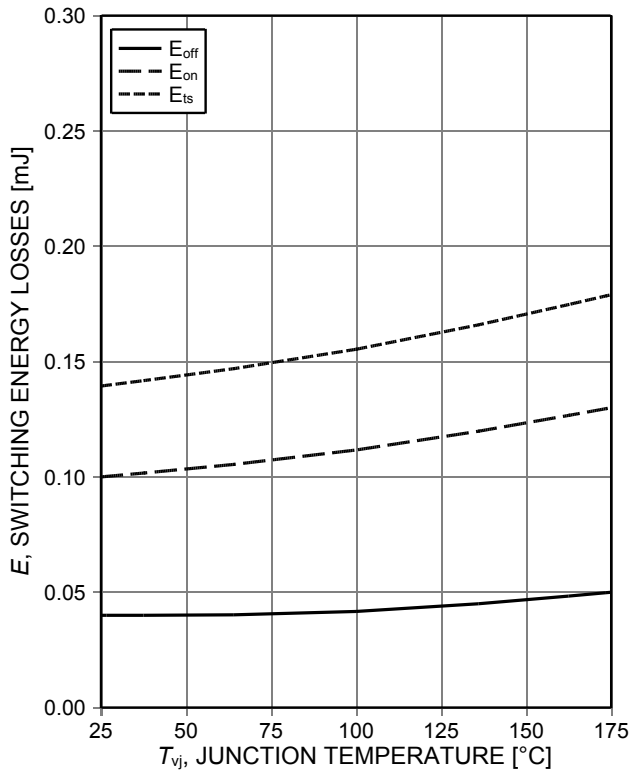


Figure 13. **Typical switching energy losses as a function of junction temperature** (inductive load,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $I_C=4A$ ,  $R_G=49\Omega$ , Dynamic test circuit in Figure E)

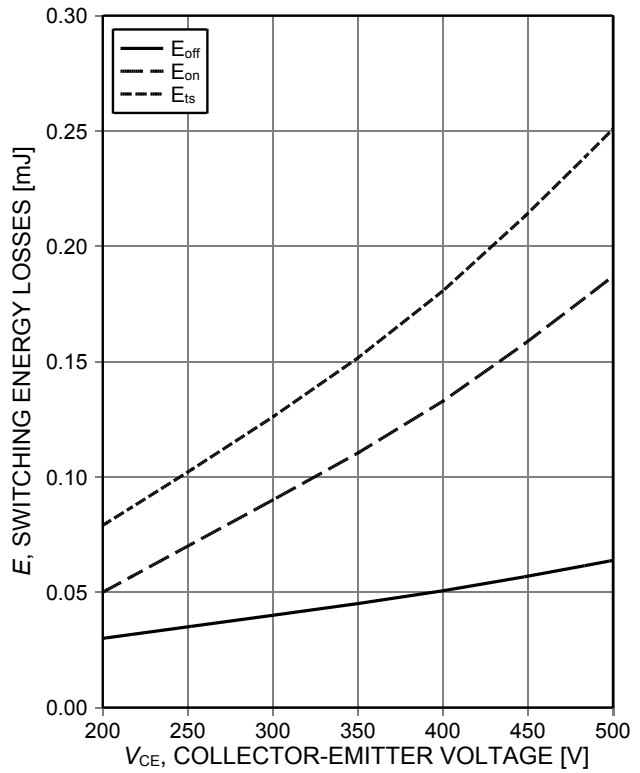


Figure 14. **Typical switching energy losses as a function of collector emitter voltage** (inductive load,  $T_{vj}=175^\circ C$ ,  $V_{GE}=15/0V$ ,  $I_C=4A$ ,  $R_G=49\Omega$ , Dynamic test circuit in Figure E)

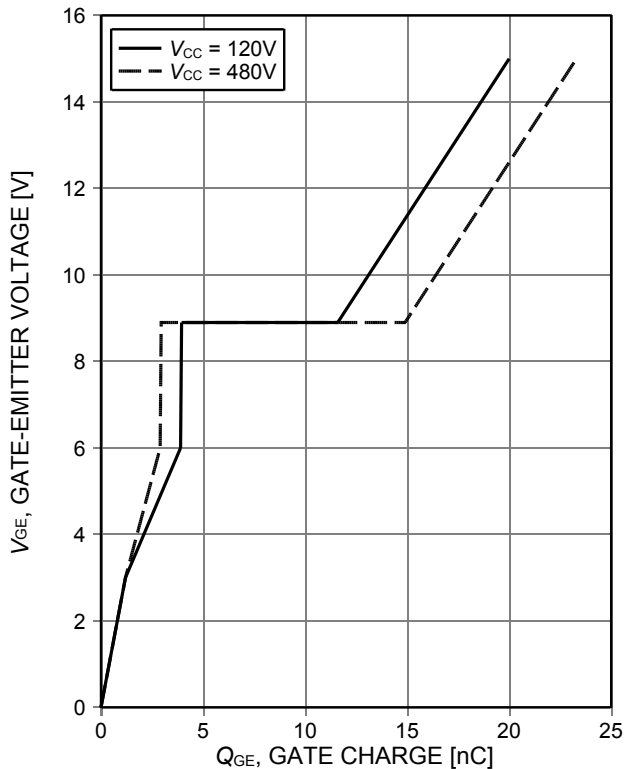


Figure 15. **Typical gate charge** ( $I_C=4A$ )

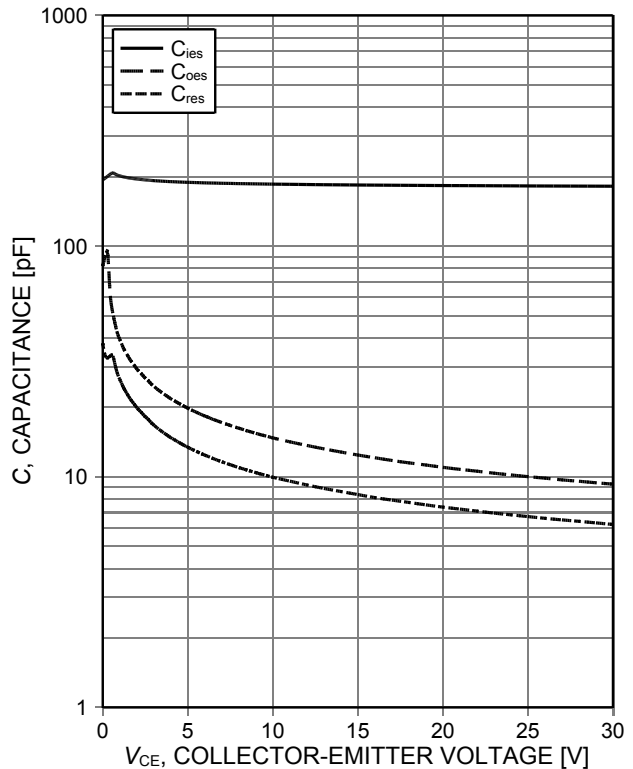


Figure 16. **Typical capacitance as a function of collector-emitter voltage** ( $V_{GE}=0V$ ,  $f=1MHz$ )

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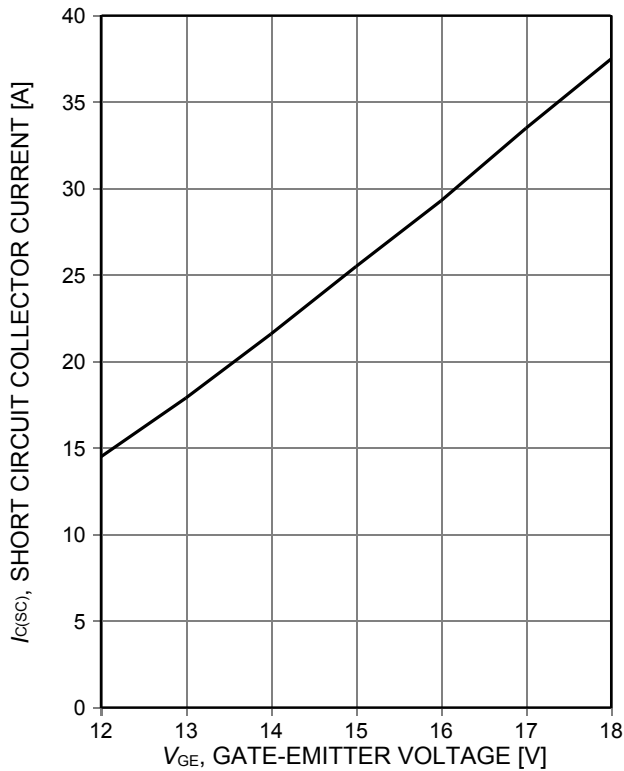


Figure 17. Typical short circuit collector current as a function of gate-emitter voltage ( $V_{CE} \leq 400V$ ,  $T_{vj} \leq 150^\circ C$ )

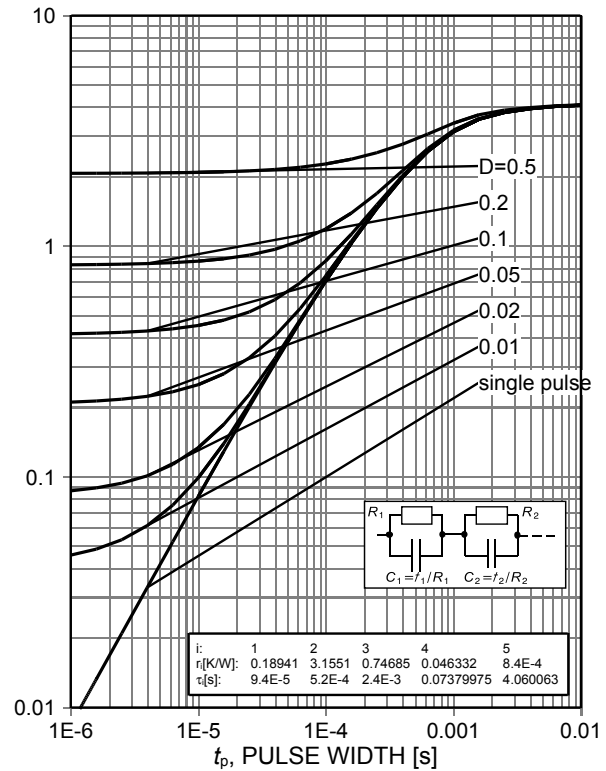


Figure 18. IGBT transient thermal resistance ( $D=t_p/T$ )

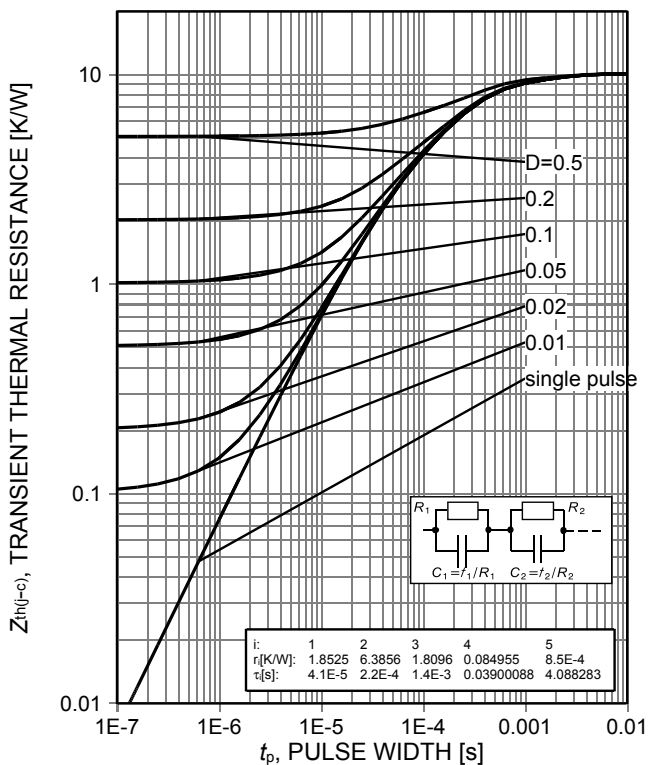


Figure 19. Diode transient thermal impedance as a function of pulse width ( $D=t_p/T$ )

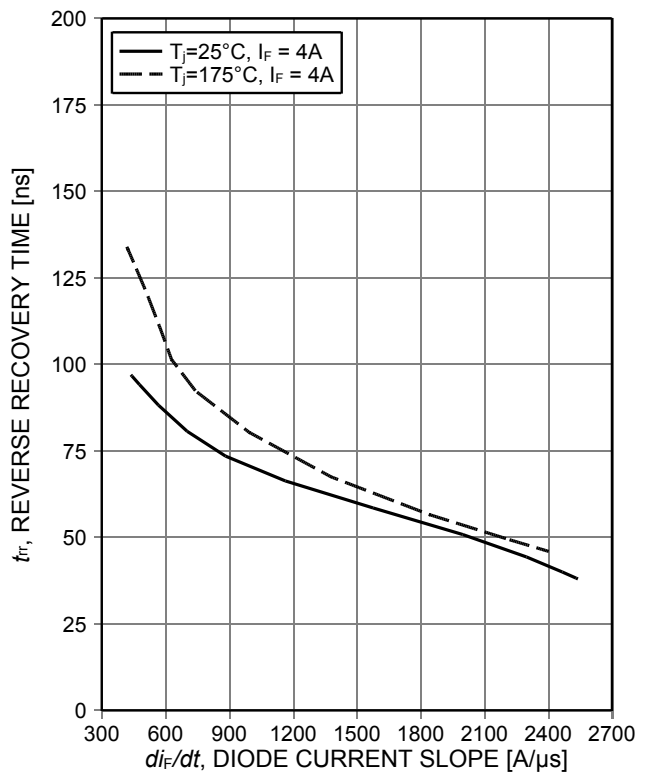


Figure 20. Typical reverse recovery time as a function of diode current slope ( $V_R=400V$ )

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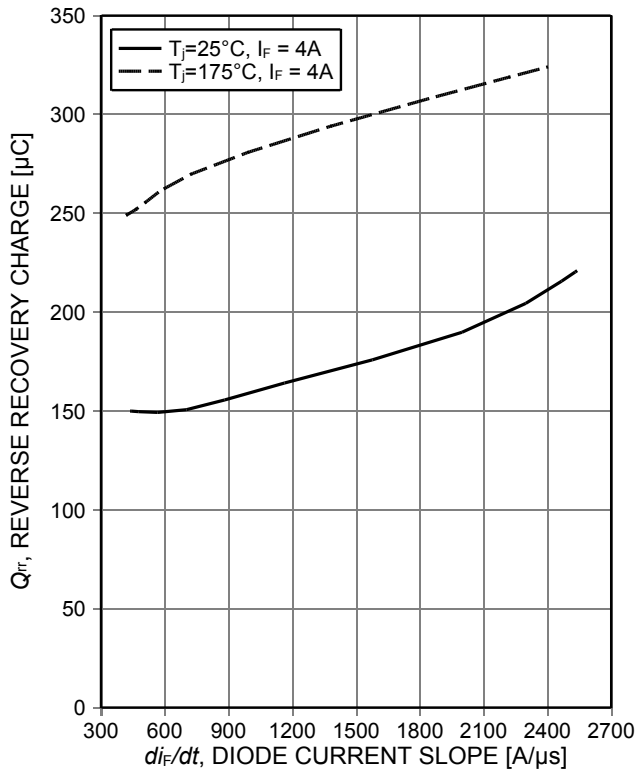


Figure 21. Typical reverse recovery charge as a function of diode current slope (VR=400V)

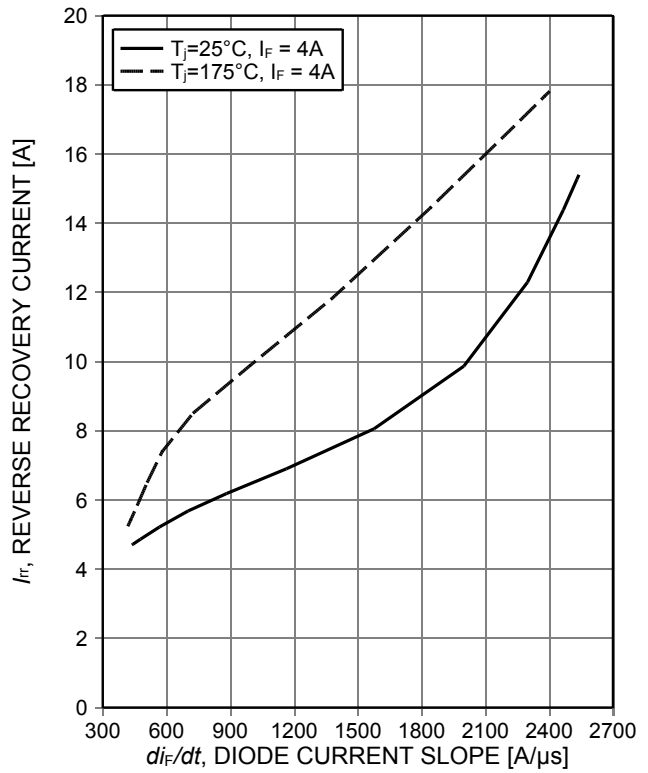


Figure 22. Typical reverse recovery current as a function of diode current slope (VR=400V)

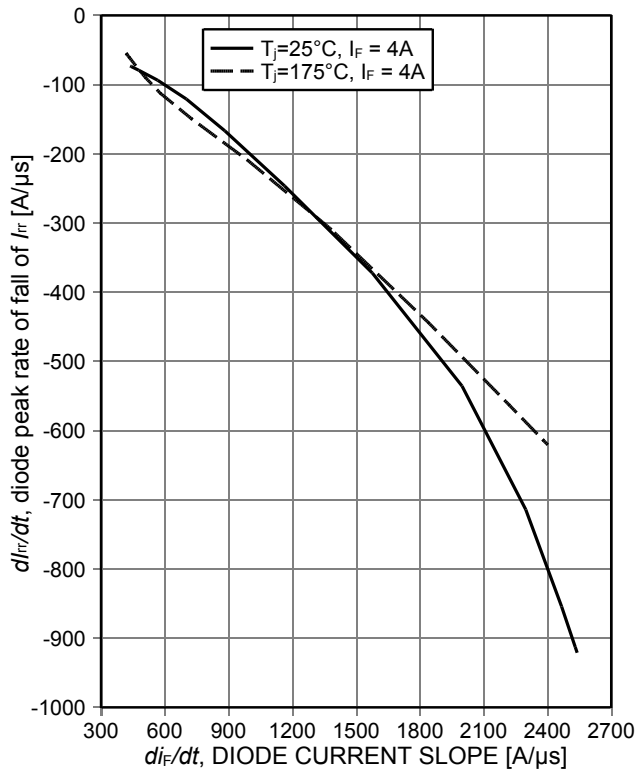


Figure 23. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope (VR=400V)

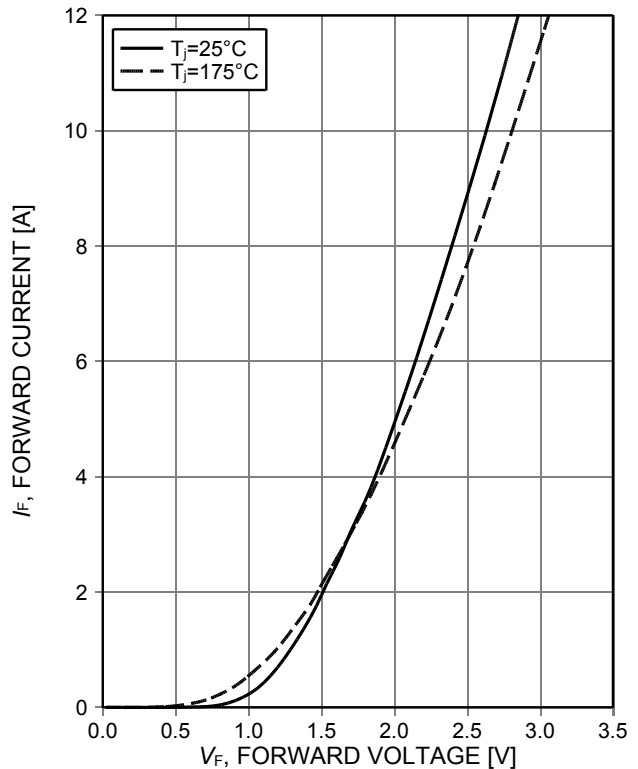


Figure 24. Typical diode forward current as a function of forward voltage

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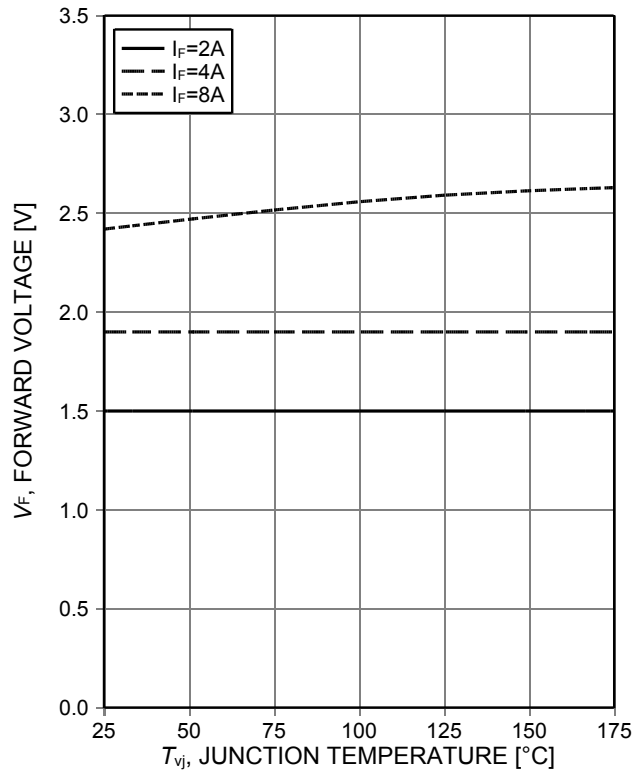
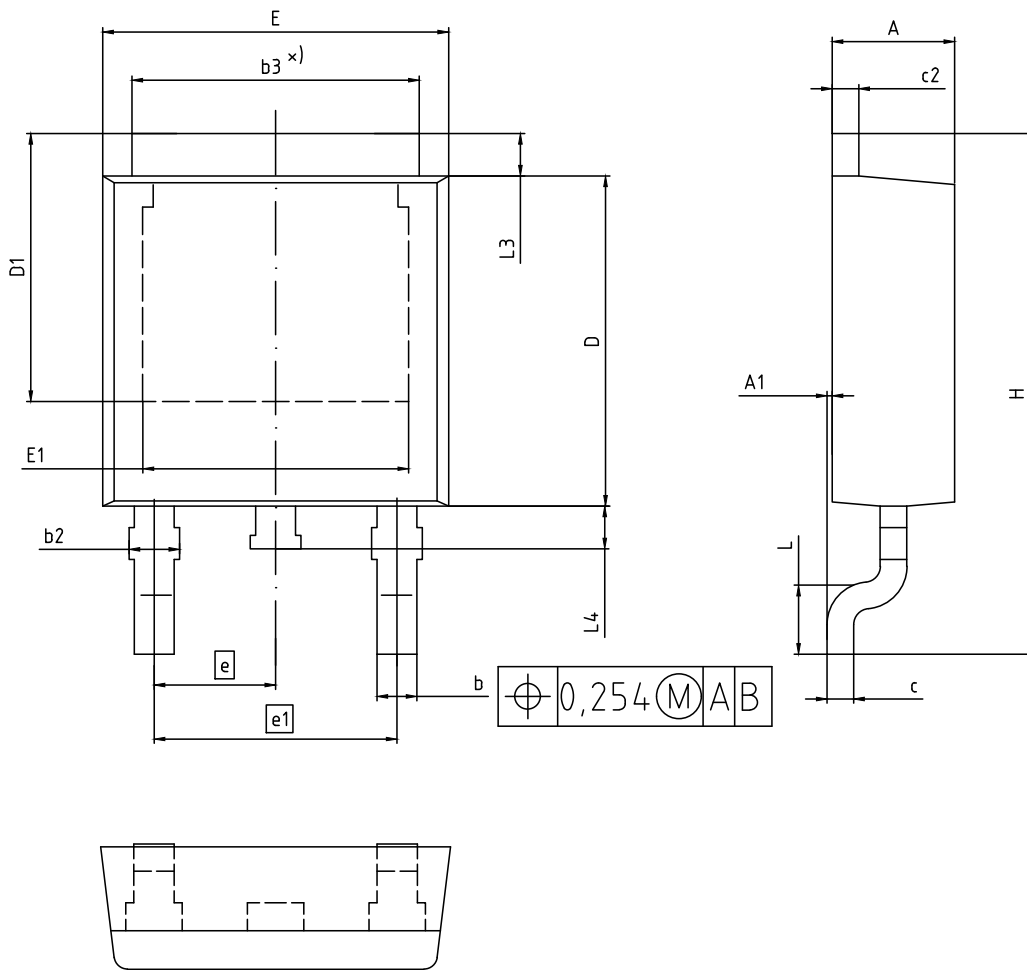


Figure 25. Typical diode forward voltage as a function of junction temperature

Package Drawing PG-TO252-3



NOTES:  
 1. ALL DIMENSIONS REFER TO JEDEC STANDARD TO-252 DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.

DIM	MILLIMETERS	
	MIN	MAX
A	2.16	2.41
A1	0.00	0.15
b	0.64	0.89
b2	0.65	1.15
b3	4.95	5.50
c	0.46	0.61
c2	0.40	0.98
D	5.97	6.22
D1	5.02	5.84
E	6.35	6.73
E1	4.32	5.21
e	2.29 (BSC)	
e1	4.57 (BSC)	
N	3	
H	9.40	10.48
L	1.18	1.78
L3	0.89	1.27
L4	0.51	1.02

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SCALE

EUROPEAN PROJECTION

ISSUE DATE  
05-02-2016

REVISION  
06

Testing Conditions



Figure A. Definition of switching times



Figure B. Definition of switching losses



Figure C. Definition of diode switching characteristics



Figure D. Thermal equivalent circuit



Figure E. Dynamic test circuit  
Parasitic inductance  $L_{\sigma}$ ,  
parasitic capacitor  $C_{\sigma}$ ,  
relief capacitor  $C_r$ ,  
(only for ZVT switching)

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## TRENCHSTOP™ RC-Series for hard switching applications

### Revision History

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IKD04N60RC2

**Revision: 2020-09-28, Rev. 2.1**

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Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.1	2020-09-28	Final data sheet

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